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The distribution and status of alien plants in a small South African town

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ABSTRACT

1. The invasion of alien plants into natural ecosystems in South Africa is a substantial conservation concern. The primary reason for the introduction of alien plants has been ornamental horticulture, and urban centres are the main sources of invasions. Small towns have high edge: area ratios which favour the launching of invasions into surrounding areas. There is, however, a shortage of information at the global and local scale on the occurrence, distribution, and status of alien plants in an urban context.
2. We surveyed all alien plants in the small town of Riebeek Kasteel in the Western Cape, South Africa, to gain insights on where to find alien plant species, and to assist with future studies and the management of alien floras in small towns.
3. We surveyed publically accessible land, recording the abundance of all alien plant species every 10 m of road. A species accumulation curve was compiled to show the rate at which new species were encountered. This approach was used to test the efficacy of different sampling strategies.
4. Two hundred and ninety eight alien plant taxa were recorded in five land-use types. Half of the alien plant species recorded were naturalised within the town, while a third were invasive in the region (the Berg River catchment). 95% of the taxa, including many invasive species, occurred in gardens or adjoining road-sides, highlighting the invasion risk posed by ornamental horticulture. The most efficient way of collecting data on alien plant distribution for this town would have been to survey roads in the town centre first, rather than urban-edge roads and industrial areas.
5. Synthesis and applications: The gardens of small towns in South Africa harbour a high diversity of alien plants, many of which are already invasive or are potentially invasive. As the alien flora differs markedly between gardens, it is difficult to extrapolate generalised rules of thumb on where to survey. This means that compiling accurate inventories of alien plants in urban areas requires substantial search effort and taxonomic expertise.

1. Introduction

Alien plant invasions are a major conservation concern in many parts of the world (Mack et al., 2000), including South Africa (Richardson et al., 2011a). Urban areas are hotspots for the introduction of alien species (Vitousek et al., 1997; Pyšek, 1998), particularly of plants used for ornamental horticulture (Reichard and White, 2001; Sanz-Elorza et al., 2008; Marco et al., 2010; Asmus and Rapson, 2014). It is therefore not surprising that there is a strong correlation between human population density and alien plant species richness (Spear et al., 2013; Aronson et al., 2014a, 2014b). Urbanisation is increasing in all regions of the world, and more than half of the global human population now live in cities and towns (United Nations, 2016). This trend is likely to increase into the future (Grimm et al., 2008). While increasing urbanisation is likely to exacerbate problems associated with cities as sources of alien propagules, historical patterns and processes mean that there is already a large invasion debt: even without further introductions, many species that are already introduced will become invasive over time (Rouget et al., 2016).

Despite these findings and the obvious risks, few studies have examined the structure and patterns of alien plants within urban spaces. Those that have been done have focussed on large cities (e.g. Alston and Richardson, 2006; Lambdon et al., 2008; Botham et al., 2009; Garcillán, 2014; Lenda et al., 2014; Aronson et al., 2014b). While large cities typically have more alien species than small rural towns and villages, and are often the first places in a country to which a plant is introduced, smaller towns typically have a relatively larger urban-wildland interface (a notable exception is the City of Cape Town with the Table Mountain National Park embedded within its boundaries). A large urban-wildlife interface means that established urban alien plant species with expanding populations only need to cover a relatively small geographical distance before reaching surrounding natural areas

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(Moreira-Arce et al., 2014). This effect was also noted by Marco et al. (2010) who observed that species planted on garden margins were more likely to escape into adjacent areas. Smaller towns are also much more numerous than big cities and so collectively represent a higher risk of contributing invasive propagules into the surrounding areas.

South Africa has enacted national legislation aimed at controlling invasive species which has implications for the urban environment (Box 1).

However, most municipalities do not have the capacity to service the requirements of NEM:BA (Irlich et al., 2017). While some information is available at a broad environmental scale on the existence and general location of alien plant species outside of cultivation that will assist municipalities in compiling their plans (Henderson and Wilson, 2017), there is very little information on the location, identity, and distribution of alien plants in the urban spaces in the country.

Our aims were thus to systematically map the occurrence and abundance of alien plants in a small town in South Africa, and, based on the data collected, to propose a strategic approach to guide future surveys of alien plants in small towns in South Africa. The survey strategy developed here could be used to help municipalities to meet their regulatory requirement to report on the occurrence of invasive species in urban areas. We also aimed to determine the introduction status of alien plants captured in our survey. Such information can assist managers in the identification and prioritisation of invasive species within the urban context.

2. Methods

2.1. Site description

Riebeek Kasteel is a small town of 6.9 km^2 situated within the Swartland Municipality (part of the West Coast District Municipality) in the Western Cape, South Africa (Fig. 1). The town was established in the 1860s and it currently has a population of 1144 people at a density of 179 persons/km^2 (StatsSA, 2016). The town has a mixture of residential, industrial, commercial and agricultural land uses and is bordered mainly by agricultural land (primarily vineyards) and in the west by natural vegetation of the Riebeek Kasteel Mountain and the Kasteelberg Nature Reserve. Its relatively long history and diversity of land-use types makes Riebeek Kasteel an ideal subject to investigate the patterns of distributions of alien plants in a small urban centre. In terms of its size and complement of alien plants, Riebeek Kasteel is typical of towns in the Breede River catchment (McLean et al., 2017).

Box 1
South African legislatory requirements for municipalities to manage invasive species.

The National Environmental Management: Biodiversity Act (DEA, 2014; NEM:BA, Act 10 of 2004) compels "all organs of state in all spheres of government", including municipalities, to deal with invasive species by "preparing an invasive species monitoring, control and eradication plan for land under their control" (NEM:BA 2004). This plan must be compiled according to Section 76.(2) (a) of NEM:BA and should form part of each municipality's integrated development plan. Such a plan must include [76(4)(a–f)]:

a) detailed lists and descriptions of listed invasives;
b) a description of the parts of land infested;
c) an assessment of the extent of each infestation;
d) a status report on the efficacy of (any) previous control measures;
e) current measures to monitor, control and eradicate invasives;
f) measurable indicators of progress and success of above control measures (including a timeline of projected completion).

Plans must include the land under urban settlement within each municipality's jurisdiction.

2.2. Field-survey

We treated roads in the town as transects for our survey and sampled all publically accessible roads in the town. While we covered all such roads over the course of the study, we were not prescriptive in our choice of routes that we took during the survey (i.e. roads were not selected strategically, but haphazardly). This survey was undertaken by the same two observers (PM and SK-K) over eleven non-consecutive days in the spring of 2015 (August–October). While it is possible that a few additional plants might have been found if we had sampled in other seasons, the vast majority of plants in the area flower and/or have foliage in spring. We walked each public road taking a GPS waypoint every 10 m. This was done for both sides of each road because it was not feasible to accurately identify or count individuals on the far side of roads given the distance and the increased potential of obstructions between the viewer and the specimens. At each waypoint we recorded the identity and number of each alien plant species visible within three observation zones. The observation zones were: 1) within 1 m of the observer; 2) within a radius of 10 m (until the next observation point or into a garden/property up until the view was obstructed by a tall building); 3) plants appearing above or behind visual obstructions like buildings which would not likely be captured from another street (the datasheet used for this survey is shown in Supplementary Table 1). Species recorded at one waypoint were not included at the next waypoint to avoid double counting. This methodology enabled us to extend the sampling range of each point to capture information on plants which may be located relatively far from the road (e.g. back gardens).

Numbers of individuals of all taxa observed were calculated as number of stems for large, woody species, and as the canopy cover (in m^2) for herbaceous or spreading/creeping species.

We also noted points where no species could be observed (for example when standing on a paved driveway and where anything visible in Zones 2 or 3 would be captured by the next or previous observation waypoint). The growth stage of individuals was recorded at each waypoint as either 'adult' (ideally there was evidence of flowering or fruiting, but occasionally plants were coded as adults simply on the basis of their size), or 'seedling' or 'young, non-reproductive individual'. A measure of the degree of cultivation at each sampling point was taken as either high (well-tended gardens and mowed open areas like parks and playgrounds); medium (less-well maintained gardens and public open spaces); or low (obviously unmanaged areas). Whether an individual was purposefully planted or naturally recruiting was noted and we attempted to determine whether the species had the opportunity to recruit at each sampling point (was it on open, fertile ground, or embedded within paving, for example) and whether there was evidence of recruitment (i.e. the presence of unplanted propagules in the vicinity). The land-use type was also recorded at each waypoint for each observation zone according to five categories: Agricultural Areas; Garden; Curbs (i.e. roadsides bordering gardens or agricultural land); Urban Green Space (we used an adaptation of the definition used by Cilliers et al. (2012) which includes publically accessible spaces within the town, whether formally gardened or not including parks, churches and open plots); and Industrial Areas (including sites of heavy industry, warehouses, commercial space and the waste water treatment works). Lastly, we included field-notes, e.g. that some roadside plants appeared to have grown from dumped garden waste.

While we limited our survey to publically accessible roads, most properties in the town had either no perimeter walls or only low ones, which effectively gave visual access to most species growing in private gardens.

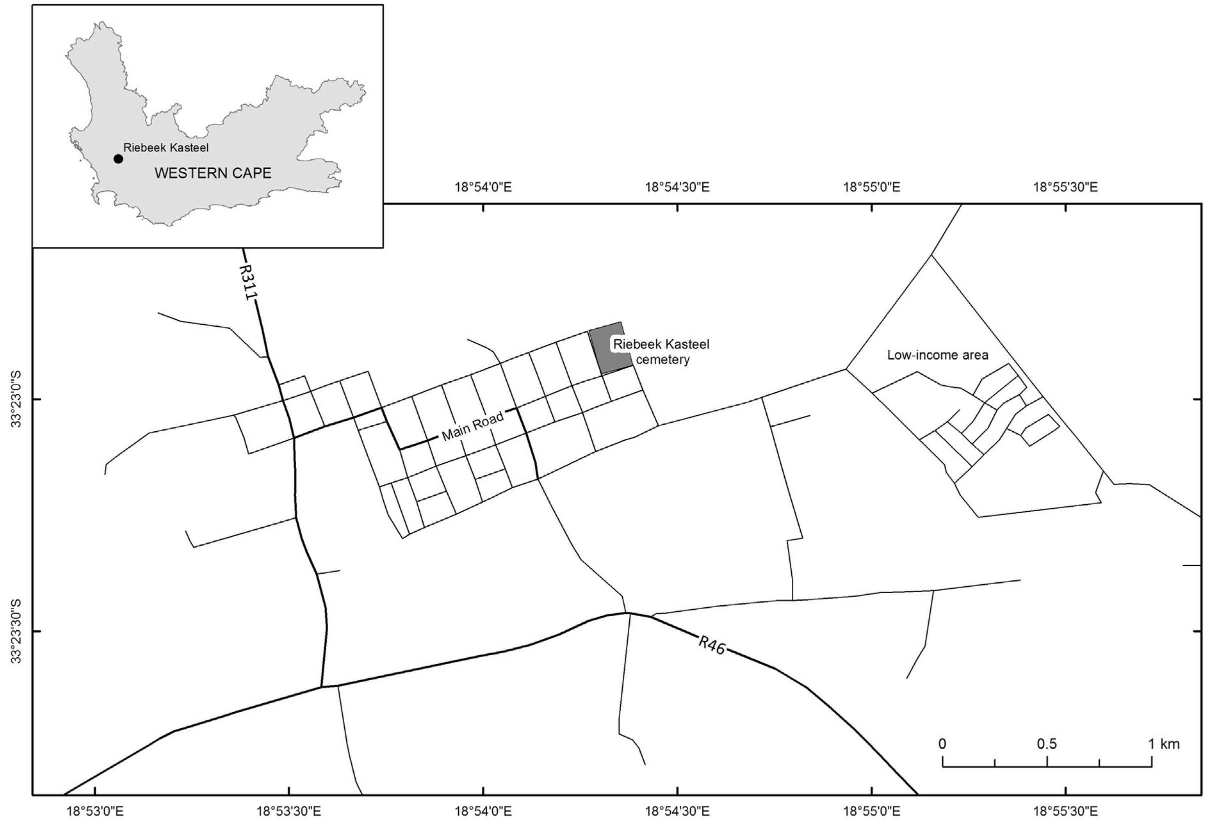

Fig. 1. Location of Riebeek Kasteel within the Western Cape province of South Africa. Detail shows the town's basic roadmap indicating the main road through the town, the low-income area, and the cemetery.

In some cases, identification to species level was not possible in the field, in which case a photograph and/or a physical sample (if possible) were taken. These were later sent to a taxonomist for identification. Species names were cross-checked for synonymy using The Plant List (Version 1.1, 2013; accessed January 2016) or the advice of taxonomists. Some individuals of the genera *Cupressus*, *Eucalyptus*, *Melaleuca* (including *Callistemon*) and *Pinus* require close-up examination for positive identification to species or subspecies level. This is because of subtle variations in leaves, bark, fruit or flower morphology. Most surveyed land was privately owned and thus direct access was not always possible, which prevented the close scrutiny required for species-level identification for some individuals. Analyses were thus done at the genus level for these groups of plants to avoid any representational biases.

Terminology in this paper follows the definitions proposed in Blackburn et al. (2011) and Richardson et al. (2011b). Taxa were thus classified as 'alien' if their presence in the region is the result of human actions. Those alien taxa that overcome reproductive barriers such that they can produce multi-generational, self-replicating populations without human assistance (or despite human intervention) are termed 'naturalized'. Some naturalized species are able to produce large numbers of reproductive offspring which have the potential to disperse over long distances. When this happens far from sites of initial introduction, the taxa were categorized as 'invasive'.

2.3. Analysis of alien plant distribution by land-use type

To examine patterns in the distribution of alien plants according to land-use type, we first tested for unequal variances using Welch's Test before running a pairwise, post-hoc Tukey *t*-test to test for significant differences. The same tests were also applied to the data on the abundance of alien plant species found within each land-use type (taking a measure of 1 m^2 of spreading plants as equal to one individual plant for those growth forms where this could be easily counted so that their numbers could be compared with those of the woody species). We then tabulated the 20 most abundant plant species in each land-use type for comparative analysis.

2.4. Model to determine optimal search-strategy

We analysed the rate of species accumulation by using the specaccum function in R 3.3.1 (vegan package; Oksanen et al., 2013). We ran the package using the data as it was sampled in the survey, then again using the package's default setting which samples all sites in random order to generate a baseline and target data accumulation rates. On these curves we calculated the number of data points it would take to encounter 50% and 80% of the total species pool.

Sampling random points is not sensible in practice, as it would be difficult to do, and would potentially take more effort (relocating across town at random whilst trying to ensure all possible data points were captured and without duplicating entries). So we had to consider other approaches to sample the town strategically to capture the greatest amount of data for the least effort. Our first approach was to consider those locations which had the highest number of species per data point. We plotted these data using the Kernel Density tool in Spatial Analyst ArcMap 10.4 (Suppl. Fig. 1). This allowed us to return to the data and re-run the species accumulation curve based on decreasing species density patterns.

When this approach did not result in a significantly more rapid accumulation of data than our original, haphazard survey method, we considered another series of strategies based on the systematic sequential sampling of particular roads within the town. For this approach, data were coded according to their location on different discreet road types within the town. We defined seven road types from our transect data: Main road = the main commercial route through the town; Access roads = arterial roads linking the town to major roads in the region; Urban edge roads = those roads characterised by a single erven which were directly exposed to areas outside of the town (i.e. not adjacent to another garden); Perpendicular roads = roads running perpendicular to the town's main road; Parallel roads = roads running perpendicular to the town's Main road; Industrial roads = roads defined by industrial activity (e.g. waste-water treatment works, industrial/manufacturing zones, electricity substations); and Low-income roads = Roads in low-income areas. We defined “low-income areas” as those portions of the town which were the result of racial and economic separation under apartheid legislation before 1994 (see McConnachie and Shackleton, 2010; Shackleton and Blair, 2013).

To devise and compare strategies for rapidly accumulating species richness using sequences of the different road types, we first generated a table of all the possible road combinations from the seven categories described above. Each road type's species richness data consisted of a matrix of presence/absence data for that road type for all the alien plant species observed in the town. We could then test sequential combinations of road types to see which new road types added the most novel species to the cumulative richness for the group. This was repeated for all levels of combinations (e.g. choosing just a single road type; choosing two road types; choosing three road types; etc.). For each level, we noted the best combination's proportion of the total species count and the effort required to reach this number (as a proportion of the total data points required).

2.5. Introduction status assessment

We determined the introduction status of all alien plant species encountered in the town using categories as defined in the Unified Framework on Biological Invasions (Blackburn et al., 2011). To do this we filtered the results of species occurrence by whether they were purposefully planted by humans and whether they were recruiting without assistance (i.e. All ‘Alien’ species were split into Naturalised or Not Naturalised). To determine which species were spreading “in the wild” and are thus invasive outside this urban setting, we referred to the regional literature on invasive and problematic plant species (Henderson, 2001; Bromilow, 2010), and plotted the abundance records of this set to indicate the most successful species within this group.

3. Results

3.1. Sampling effort

We sampled 7807 waypoints throughout Riebeek Kasteel covering a distance of c. 60 km. The survey took 11 days to complete, but because on some days two researchers were working simultaneously in the field, the survey required 16 person-days in total. We found 298 species of alien plants in the town of which 98 (33%) are listed as invasive under South African legislation (DEA, 2014) (see Appendix A for a full list of alien plant species recorded during this survey).

3.2. Distribution

The diversity of alien plant species encountered per land-use type differed significantly (Welch = 42.3, d.f. = 4, $P < 0.001$) as did the abundance of plants (Welch = 9.57, d.f. = 4, $P < 0.001$). Most species were found in Gardens; this land-use type contained 84% of all species recorded (Table 1). Species diversity in Gardens was significantly different ($P < 0.001$) from Curbs, Urban Green Spaces and Agricultural Areas and different ($P < 0.05$) from Industrial Areas. Gardens also had the highest number of data points, however, which meant that the average number of species per data point was the lowest for any land-use type measured (0.06, Table 1). Greater search effort was thus required to gain the species richness contained in this land-use set. While Agricultural and Industrial Areas have more species per data point on average (0.14 and 0.18 respectively), these land-use types had very low overall species richness (15% and 29% respectively). Gardens were also noteworthy in having a very high range of species per data point, (between 0 and 20); their maximum was 40% higher than that of the next highest land-use category (Curbs, at 12 species per data point).

The lowest contribution of species to the total was recorded in Agricultural Areas (only 46 species out of the total of 298), but these areas accounted for the greatest abundance of plants. Industrial Areas and Urban Green Spaces had moderate representations of total species diversity but abundance was very low for plants in Industrial Areas (3%).

When considering the most abundantly occurring plants within each land-use type, it was evident how many are listed as invasive under national legislation or within literature for problem plants in the region (Table 2). Industrial Areas and Urban Green Spaces had only one and two plants respectively within the top 20 most abundant species that were not problematic plants or listed invasives. Problematic plants or listed invasive species account for the majority (78%) of the most abundant plants for all land-use types.

3.3. Sampling strategy models

Fig. 2 shows the species accumulation curve based on the field-survey. In our survey, 80% of species were encountered after 1756 data points (out of a total of 2742; or 64% of the total survey effort). It also indicates a fairly steady accumulation of novel species for increasing sampling effort, i.e. there was no obvious flattening off of the curve to indicate saturation of species diversity as the survey progressed. According to this graph, roughly 20 novel species were found per day at a fairly consistent rate after the initial 2 days of survey. If our survey had selected random points throughout the town until all possible points were sampled, it would have resulted in a more rapid accumulation of species richness than our field-survey (as indicated by the default curve drawn by the speccacum function; Fig. 2). However this strategy would be unrealistic and time consuming.

We noted, however, that when looking at the species density of sampling points (Suppl. Fig. 1), there appeared to be patterns of density on main access roads into the town as well as roads on the urban edge. To test whether this observed pattern would provide a useful strategy for more rapidly accumulating data, we re-ordered the field-survey data according to descending species density per data point and re-ran the

Table 1
The distribution of species richness and abundance of alien plants observed across five land-use types within the small town of Riebeek Kasteel, South Africa. The data on total number of species shown, is the total number of species found within that land-use type. Given plants can be found in several land-use types, these numbers add up to more than the total number of species shown. Data points refers to the number of data points that were captured for each land-use type. We also included in parentheses the range of species number recorded per data point for each land-use type.

	Agricultural Area	Garden	Industrial Area	Curbs	Urban Green Spaces	Total
Total number of species	46 (15%)	249 (84%)	85 (29%)	196 (66%)	93 (31%)	298
Abundance of plants	92,809 (70%)	13,278 (10%)	3335 (3%)	8588 (6%)	14,791 (11%)	132,799
Data points	329	3997	453	1754	867	7400
Average number of species per data point	0.14 (0–7)	0.06 (0–20)	0.18 (0–8)	0.11 (0–12)	0.11 (0–11)	

Table 2
The top 20 species by abundance in each land-use type in the small town of Riebeek Kasteel, Western Cape, South Africa. Species listed as invasive under national legislation for the whole of the county or specifically for this region (DEA, 2014) are shown in **bold** type. Plants that are not regulated in the region, but are noted as invasive or problematic in the region by Henderson (2001) or Bromilow (2010), are indicated with an *.

Agricultural Areas	Garden	Industrial Areas	Curbs	Urban Green Spaces
Vitis vinifera	_Syzygium paniculatum_*	**_Acacia saligna_**	_Vitis vinifera_	_Pennisetum clandestinum_*
_Avena fatua_*	_Rosa_ sp.	**_Echium plantagineum_**	_Avena fatua_*	_Avena fatua_*
Echium plantagineum	_Pennisetum clandestinum_*	_Avena fatua_*	_Pennisetum clandestinum_*	**_Echium plantagineum_**
Vicia benghalensis	_Duranta erecta_*	_Trifolium angustifolium_*	**_Agave americana_ subsp. _americana_ var. _americana_**	**_Eucalyptus_ sp.**
Cypress	_Olea europaea_ subsp. _europaea_	_Duranta erecta_*	**_Arundo donax_**	**_Arundo donax_**
Olea europaea subsp. _europaea_	_Bougainvillia_	_Raphanus raphanistrum_*	_Erodium moschatum_*	_Cotula turbinata_*
Melia azedarach	Cypress	**_Ricinus communis_ var. _communis_**	_Rosa_ sp.	_Briza maxima_*
Acacia saligna	**_Schinus terebinthifolus_**	_Pennisetum clandestinum_*	_Bougainvillia_	_Erodium moschatum_*
Casuarina cunninghamiana	**_Arundo donax_**	_Urtica urens_*	_Syzygium paniculatum_*	**_Acacia saligna_**
_Briza maxima_*	**_Agave sisalana_**	_Erodium moschatum_*	_Bryophyllum fedtschenkoi_	_Vicia sativa_ subsp. _sativa_*
_Foeniculum vulgare_*	**_Agave americana_ subsp. _americana_ var. _americana_**	_Malva parviflora_*	**_Echium plantagineum_**	_Raphanus raphanistrum_*
Xanthium strumarium	**_Casuarina cunninghamiana_**	**_Catharanthus roseus_**	**_Pennisetum setaceum_**	**_Acacia pycnantha_**
_Raphanus raphanistrum_*	**_Melia azedarach_**	_Solanum nigrum_*	**_Catharanthus roseus_**	**_Sesbania punicea_**
_Erodium moschatum_*	**_Myoporum tenuifolium_**	_Persicaria lapathifolia_*	_Hypochaeris radicata_*	_Quercus robur_
_Pennisetum clandestinum_*	_Populus nigra_ var. _italica_*	_Olea europaea_ subsp. _europaea_	**_Agave sisalana_**	_Tropaeolum majus_*
_Cotula turbinata_*	_Agave attenuata_	_Cynodon dactylon_*	**_Casuarina cunninghamiana_**	_Olea europaea_ subsp. _europaea_
Ficus carica	**_Catharanthus roseus_**	_Syzygium paniculatum_*	**_Hakea salicifolia_**	**_Vicia benghalensis_**
Lavandula sp.	_Papaver_ sp.	**_Acer negundo_**	_Gaura lindheimeri_	**_Ricinus communis_ var. _communis_**
_Solanum nigrum_*	_Syagrus romanzoffiana_	**_Melia azedarach_**	_Cypress_	**_Agave sisalana_**
Ricinus communis var. _communis_	**_Canna indica_**	_Cotula turbinata_*	**_Populus_ x _canescens_**	**_Casuarina cunninghamiana_**

species accumulation curve to simulate sampling points in this new sequence. This 'Density dependant' approach resulted in only marginally better results (80% diversity encountered within 1479 sampling points) than those of the original survey (1756 points).

Since this was not appreciably lower in search effort, we investigated other models to sequentially sample the different road types in the town (post hoc using our original field-survey data). Table 3 shows the best results of combinations of road types in contributing to records of alien plant species richness. This shows how Parallel roads contained the biggest proportion of the town's total species richness for a single road type. If two road types are selected for survey, then the best pair is Parallel and Perpendicular roads which together account for just over 80% of the town's alien plant species richness. Sampling these two only would require 50% of the effort of a full survey. Adding a third level results in the addition of Access roads giving the highest richness for any three combinations of roads in this town. By now, the strategic selection of roads has accounted for just under 90% of the richness for just over 60% of the effort. Any new additional road types

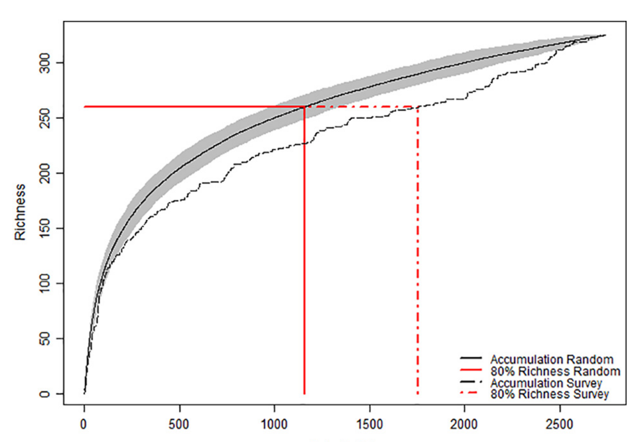

Fig. 2. Overlay of two species accumulation curves for the small South African town of Riebeek Kasteel. The solid line curve indicates the random sampling model of species accumulation provided from the data (using specaccum function in R Vegan Package) and includes the 95% confidence interval. The dotted line curve shows the accumulation of species as data were sampled in our survey, where roads were chosen by chance.

from this point typically only contribute marginal gains (around a 4% increase in richness for a 10% additional input of effort), with the last road type, Industrial, only adding 0.3% to the total richness.

Using this sequential combination assessment, the optimal order for strategically surveying the town would have been: Parallel roads; Perpendicular roads; Access roads; Low-income roads; Main road; Urban edge roads; and Industrial roads. When this sampling sequence is plotted on the accumulation curve, the results indicate it would have encountered 80% of the alien plant species diversity in the town a little over 500 data points sooner than our original survey. At 10 m per sampling point, this would have translated to walking just 5 km less – which at our sample speed would only have translated to only around 2 days less than the original survey (less than a 10% reduction in effort).

3.4. Status

The results of filtering our survey data for evidence of naturalisation and spread are shown in Table 5 according to their categorisation under the United Framework for Biological Invasions. Since our survey counted all alien plant species, the entire species pool (298 taxa) are at least B1 (transported beyond the limits of their natural range). Forty-five taxa are considered to be naturalised within the town but not yet beyond its borders, while 105 taxa are recorded in Categories D1-E (Invasive).

Sixty-nine of these taxa can be considered abundant in that each was recorded on more than 10 occasions in the town, were recruiting and spreading without human assistance and are recognised as invasive elsewhere.

4. Discussion

Our survey provided a detailed assessment of the type and number of alien plants in the small town of Riebeek Kasteel and confirmed our initial hypothesis that there would be differences in the occurrence and abundance of these species across different land-use types. The bulk of this diversity resided in gardens, but each garden was so different from the next, that one needed to sample every garden to ensure a high degree of confidence in the results, which elevated the search effort required. There were no particular broader patterns to the diversity

Table 3
Comparison of results of alien plant species sampling strategies based on road type in the small South African town of Riebeek Kasteel. All public roads were sampled at 10 m intervals in our original survey. Species presence data were then coded according to their location in seven distinct road types: Main road; Parallel [to the Main road] roads; Perpendicular [to the Main road] roads; Access roads; Urban edge roads; Industrial roads; and Low-income roads. We defined "low-income areas" as those portions of the town which were the result of racial and economic separation under apartheid legislation before 1994 (see McConnachie and Shackleton, 2010; Shackleton and Blair, 2013). We then tested all combinations of road types to determine which would result in the largest proportion of the town's total species richness. This was done for all levels of combinations (i.e. choosing one road type; choosing two road types; choosing three road types; etc.). This table displays the best results for each level of road type combination (columns 1 to 6) and indicates the proportion of the town's total species richness obtained by that combination. The proportion of effort is relative to our original survey (which took 2742 data points over 16 person days). We also indicate which roads in what sequence result in the proportion of total species richness for these best combinations shown. None of the optimal sampling strategies included Industrial roads.

Number of road types sampled	1	2	3	4	5	6
Best combination of road types	Parallel	Parallel; Perpendicular	Parallel; Perpendicular; Access	Parallel; Perpendicular; Access; Low-income	Parallel; Perpendicular; Access; Low-income; Main	Parallel; Perpendicular; Access; Low-income; Main; Urban edge
Proportion of total species richness encountered	66.0%	81.0%	89.0%	93.5%	97.5%	99.7%
Percentage of total data points surveyed	29%	50%	61%	71%	83%	97%

such that it was impossible to strategically survey the town and reduce search effort significantly. Managers should consider the high search effort required (including taxonomic expertise) in their efforts to comply with NEM:BA and should also note that the most abundant species tended to also be invasive.

4.1. Distribution

The bulk of species diversity (84%) resided in the land-use type Gardens (Table 1). To capture this diversity, though, one had to survey a large number of data points, meaning that the average number of species encountered at any given point was relatively low for this land-use type. On the other hand, the range of species here was also the broadest, with up to 20 different species being identified at a single data point. This indicates a high diversity within but also between gardens in this town.

Curbs were the next best predictor of diversity which supports other research that shows this land-use type to be a significant pathway for the movement of plant propagules, particularly on the peripheries of urban settlements (Zwaenepoel et al., 2006; von der Lippe and Kowarik, 2008; von der Lippe et al., 2013). Another explanation is that some homeowners in this town plant along road-sides as an extension of their gardens.

Few species were found in Agricultural Areas, but the species that were present were very abundant. This result is not surprising, given the typical practice of monoculture farming in the region. Also predictable was the low species richness and low abundance of plants recorded for Industrial Areas. This land-use type is typically hostile to plants and, in some cases like around electricity supply sub-stations, land is actively treated with herbicides to prevent recruitment of plants. In addition, although Industrial areas contributed 29% of the total species pool for the town, there were only two species which were found only in this land-use type (*Rumex* sp. and *Persicaria capitata*). This implies that future urban-specific surveys should not survey Industrial Areas if time is limiting.

When considering the most abundantly occurring plants within each land-use type, it was evident how many are listed as invasive under national legislation or in the literature as problem plants in the region (Table 2). Industrial Areas and Urban Green Spaces had only one and two plants respectively within the top 20 most abundant species that were not problematic plants or listed invasives. Problematic plants or listed invasive species account for the majority (78%) of the most abundant plants for all land-use types.

4.2. Sampling effort and strategy

The intensive survey resulted in a comprehensive assessment of the alien flora of Riebeek Kasteel. The high number of invasive plant species recorded in the total alien species pool (33%) is in line with findings from large cities in other parts of the world; e.g. 32% for Berlin (Kowarik, 2011). This is interesting because large cities are predicted to have a greater number of alien plant species (due to the greater number of pathways they have for ingress; e.g. ports, airports, railway hubs, etc.), yet our data suggest that the proportion of invasive species is similar in smaller towns.

The field-survey method was time-consuming and required a high level of expertise to identify the suite of alien plants encountered. This level of search effort makes it unlikely that this particular comprehensive-survey methodology will be useful or cost effective in large-scale attempts to produce alien plant inventories in other small

Table 4
Comparison of several different sampling strategies according to the number of data points each would require to encounter 80% of the total species richness for the small town of Riebeek Kasteel, South Africa. We took total species richness to equal the results from our comprehensive field-survey of Riebeek Kasteel where data points were taken at 10-m intervals along all public roads (see Appendix A.). Results were generated by re-ordering the original field-survey data according to the strategy listed and running a species accumulation curve (using the specaccum function in R Version 3.3.1). Strategies shown are (in order): Our original field-survey data in which roads were sampled in a haphazard manner; Randomised sampling strategy drawn up using the default function in specaccum where data points are sampled at random; Density dependant strategy based on decreasing density of species per sampling point (see Fig. 2); and the Best sequential road-type combination where roads were sorted in decreasing order of each road type's contribution to a cumulative alien species count (see Table 3).

Sampling strategy	Data points required to achieve 80% of total town species richness
Field-survey data	1756
Randomised sampling points	1178
Density dependant	1479
Best sequential road type combination	1154

Table 5
Application of the Unified Framework (Blackburn et al., 2011) to the survey of alien plant species from the small town of Riebeek Kasteel, Western Cape, South Africa. We indicate the steps at which and degree to which the pool of total species (298) is reduced to reflect landscape-level invaders present in the town. We condensed the Unified Framework into four broader categories and added the initial category of Present, which could equate to B1 on the Framework. "Alien but not naturalised" corresponds to categories B1-C1 from the Framework, while "Naturalised but not invasive" corresponds to categories C2-C3. Lastly, "Invasive" corresponds to categories D1-E from the Unified Framework.

Condensed broad categories of introduction status	Number of species recorded in Riebeek Kasteel
Present	298
Introduced but not naturalised	148
Naturalised but not invasive	45
Invasive	105

towns. When we plot the species accumulation curve according to the way it was collected in this survey (streets and directions chosen by chance) (Fig. 2), it is clear that there is no appreciable levelling off of the curve over time. This lack of saturation indicates that alien plant species diversity is high across the town such that we encountered novel species fairly regularly until completion of the survey, which explains why such a high degree of search effort was required.

However, it is possible that this is a reflection of the lack of underlying 'search strategy' in the survey methodology. For example, we noted how certain areas like the main roads into the town and urban edge roads had the greatest number of species per data point (Suppl. Fig. 1). For this reason we attempted to stratify the survey results by road sampled, using the more species-dense locations of main access routes into the town and urban edge roads before sampling other roads within the town. Interestingly, this sampling strategy was only marginally better than the haphazard sampling strategy used in the original survey (Table 4). We conclude that this effect was due to the lack of diversity between each data point on these roads. Many of the species located at these points were agricultural-origin problem species like *Avena fatua* and *Echium plantagineum* which were spreading towards the town along disturbed roadsides. Although each data point might contain more than 15 species, the predominance of these problematic plant species meant that the following point would contain the same species component and thus add nothing new to the novel species accumulation curve. Thus, the density of species sampled at any point is not indicative of the diversity over the whole town.

To determine a better strategy, we tested models of species accumulation based on the sequential addition of different road types. What was apparent, however, was that, in order to gain sufficiently high species richness figures, search effort remained very high. Spatial autocorrelation within the town prevented any strategy from performing meaningfully better than the simulation's randomised sampling strategy; meaning the best saving in effort we could generate using this post hoc approach was less than 10% of the effort of our full survey.

Interestingly, despite some minor changes to the rates at which species were recorded, none of the curves we ran indicated any degree of saturation, suggesting that no matter how the town was sampled, novel species would continue to be recorded as the search area increased. Even the default curve where sites are sampled at random (Fig. 2) showed no levelling off and all strategic sampling methods attempted resulted in only marginal reductions in search effort. These results echo those obtained in a larger town in South Africa (Tlokwe City) by Lubbe et al. (2011) as well as those from a study in the UK (Smith et al., 2006). This reflects the very high species diversity typical of gardens and garden plantings in urban environments, which is also supported by our results of species richness by land-use type in this town. Each garden effectively represents a clean slate for the landowner to plant whatever species they desire or can locate (or that they can keep alive, if the local environmental and climatic conditions differ extensively from those in the species' natural range). There is thus no necessity for any two gardens to have similarity in their species composition and, as pointed out by Smith et al. (2006), the available pool of alien plant species in any garden is a function of the range of species available through the horticultural trade which is a major pathway for plant invasions worldwide (Richardson et al., 2003; Dehnen-Schmutz et al., 2007a, 2007b; Foxcroft et al., 2008; Lambdon et al., 2008). This explains much of the diversity in alien floras of cities (Sanz-Elorza et al., 2008; Marco et al., 2010; Asmus and Rapson, 2014). The availability of additional species through the global internet trade in recent years only enhances this effect (Lenda et al., 2014). This site/garden-specific diversity means that in an urban plant survey, one finds novel species fairly consistently until the entire area is surveyed. This finding is important for other studies involving species estimates from partial urban surveys, as these will need to consider the number of gardens not sampled in order to extrapolate more accurately.

4.3. Status

Our data show that half of the alien plant species recorded for this small town are at least naturalised within this urban space. While nearly a third of the total species pool shows evidence of invasion in the region, the 46 naturalised but not invasive species should be subjected to risk analysis to determine whether they contribute to invasion debt (as contemplated by Rouget et al., 2016).

5. Conclusions

The alien plant flora of this town comprised mostly problematic plants and listed invasive species which may have important implications for the surrounding area which is subjected to increased propagule pressure from these problem plants. The most abundant species are those most likely to be at least naturalized but potentially invasive, so management attention should focus on these. These results imply that small towns have the potential to be major contributors of propagules which may launch new invasions (or sustain existing ones) in the areas that surround them.

Indications of the type and status of alien plants within urban areas is an important consideration for municipalities under NEM:BA, but due mainly to context dependence and the heterogeneity between gardens, our results indicate that accurate assessments require a high level of taxonomic knowledge and a large investment in search effort.

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Supplementary Table 1: Data sheet used to capture a range of information for each waypoint marked in the field.

DATE:			TOWN:					Recruiting?		
Waypoint	**Obs Zone**	**Species**	**Number of individuals**	**Square metre cover**	**Growth Stage**	**Planted Y/N**	**Land use Type**	**Could it recruit?**	**Has it recruited?**	**Notes:**

Appendix A: Table of full list of alien plant species recorded for the small South African town of Riebeek Kasteel where all public roads were surveyed at 10 m intervals in spring 2015. Abundances were recorded as stems of woody plants or 1 individual equivalent to every 1m^2 for creeping and spreading plants. Each species' category listing under the National Environmental Management: Biodiversity Act (NEM:BA) Regulations for the Western Cape province of South Africa is noted (Department of Environmental Affairs 2014).

Taxon	Family	NEM:BA Category	Abundance
Acacia mearnsii **De Wild.**	Fabaceae	2	70
Acacia melanoxylon **R.Br.**	Fabaceae	2	31
Acacia podalyriifolia **G.Don**	Fabaceae	1b	29
Acacia pycnantha **Benth.**	Fabaceae	1b	328
Acacia saligna **(Labill.) Wendl.**	Fabaceae	1b	1211
Acanthus mollis **L.**	Acanthaceae		10
Acer negundo **L.**	Sapindaceae	3	93
Acer palmatum **Thunb.**	Sapindaceae		2
Acer **sp.**	Sapindaceae	3	3
Aeonium arboreum **(L.) Webb & Berthel.**	Crassulaceae		15
Agave americana **L. subsp.** ***americana*** **var.** ***americana***	Agavaceae	3	603
Agave americana **var.** ***mediopicta*** **Trel. 'Alba'**	Asparagaceae		4
Agave attenuata **Salm-Dyck**	Asparagaceae		286
Agave sisalana **Perrine**	Asparagaceae	2	464
Ageratina adenophora **(Spreng.) R.M.King & H.Rob.**	Asteraceae	1b	10
Ageratum conyzoides **L.**	Asteraceae	1b	1
Ailanthus altissima **(Mill.) Swingle**	Simaroubaceae	1b	10
Allium triquetrum **L.**	Alliaceae		10
Alstroemeria **sp.**	Alstroemeriaceae		2
Ammi majus **L. var.** ***glaucifolium*** **(L.) Godr.**	Apiaceae		4
Amphilophium buccunatorium **(DC.) L.G.Lohmann**	Bignoniaceae		52
Anredera cordifolia **(Ten.) Steenis**	Basellaceae	1b	67
Araucaria heterophylla **(Salisb.) Franco**	Araucariaceae		22
Arundo donax **L.**	Poaceae	1b	1159
Atriplex **sp.**	Amaranthaceae	1b/2	5
Austrocylindropuntia cylindrica **(Juss. ex Lam.) Backeb.**	Cactaceae	1a	1
Austrocylindropuntia subulata **(Muehlenpf.) Backeb. subsp.** ***exaltata*** **(A.Berger) D.R.Hunt**	Cactaceae	1b	8
Avena fatua **L.**	Poaceae		9835
Bauhinia variegata **L. var.** ***variegata***	Fabaceae	3	16
Betula pendula **Roth**	Betulaceae		5
Bidens pilosa **L.**	Asteraceae		20
Bougainvillia **sp.**	Nyctaginaceae		718

Brachychiton acerifolius **(A.Cunn.) F.Muell.**	Malvaceae		10
Breynia disticha **J.R.Forst. & G.Forst.**	Euphorbiaceae		28
Briza maxima **L.**	Poaceae		555
Bromus **sp.**	Poaceae		37
Brugmansia × candida **Pers.**	Solanaceae		9
Brunfelsia pauciflora **(Cham. & Schltdl.) Benth.**	Solanaceae		14
Bryophyllum delagoense **(Eckl. & Zeyh.) Schinz**	Crassulaceae	1b	2
Bryophyllum fedtschenkoi **(Raym.-Hamet & Perr.) Lauz.-March.**	Crassulaceae		200
Buddleja madagascariensis **Lam.**	Scrophulariaceae	3	2
Caesalpinia ferrea **Tul.**	Fabaceae		72
Callistemon **sp.**	Myrtaceae	3	170
Camellia **sp.**	Theaceae		2
Canna indica **L.**	Cannaceae	1b	236
Carica papaya **L.**	Caricaceae		12
Carya illinoinensis **(Wangenh.) K.Koch**	Juglandaceae		16
Casuarina cunninghamiana **Miq.**	Casuarinaceae	2	579
Catharanthus roseus **(L.) G.Don**	Apocynaceae	1b	444
Celtis **sp.**	Ulmaceae	3	13
Centranthus ruber **(L.) DC.**	Valerianaceae	1b	72
Cereus hildmannianus **K.Schum.**	Cactaceae	1b	8
Cereus jamacaru **DC.**	Cactaceae	1b	178
Cereus **sp.**	Cactaceae	1b	5
Cestrum elegans **(Brongn.) Schltdl.**	Solanaceae	1b	5
Cestrum laevigatum **Schltdl.**	Solanaceae	1b	10
Chamelaucium uncinatum **Schauer**	Myrtaceae		4
Chenopodium album **L.**	Chenopodiaceae		25
Cinnamomum camphora **(L.) J.Presl**	Lauraceae	3	24
Cirsium vulgare **(Savi) Ten.**	Asteraceae	1b	2
Cistus parviflorus **Lam.**	Asteraceae		2
Cistus x argenteus **Dans.**	Cistaceae		1
Citharexylum spinosum **L.**	Verbenaceae		6
Citrus limon **(L.) Burm.f.**	Rutaceae		53
Citrus sinensis **(L.) Osbeck**	Rutaceae		1
Cleistocactus **sp.**	Cactaceae		5
Convolvulus **sp.**	Convolvulaceae		5
Coprosma repens **A.Rich.**	Rubiaceae		1
Cortaderia selloana **(Schult.) Asch. & Graebn.**	Poaceae	1b	1
Corymbia ficifolia **(F.Muell.) K.D.Hill & L.A.S.Johnson**	Myrtaceae		12
Cosmos **sp.**	Asteraceae		100
Cotoneaster **sp.**	Rosaceae	1b	14
Cotula turbinata **L.**	Asteraceae		693

Crotalaria agatiflora **Schweinf. subsp. *agatiflora***	Fabaceae	1b	4
Cupressus **sp.**	Cupressaceae		699
Cydonia oblonga **Mill.**	Rosaceae		5
Cylindropuntia fulgida **(Engelm.) F.M.Knuth var. *mamillata* (A.Schott ex Engelm.) Backeb.**	Cactaceae	1b	4
Cylindropuntia fulgida **(Engelm.) F.M.Knuth var. *mamillata* (A.Schott ex Engelm.) Backeb. forma *monstrosa***	Cactaceae	1b	2
Cynodon dactylon **(L.) Pers.**	Poaceae		130
Datura stramonium **L.**	Solanaceae	1b	65
Disocactus **sp.**	Cactaceae	0	1
Duranta erecta **L.**	Verbenaceae		797
Echeveria gibbiflora **DC.**	Crassulaceae		100
Echinocereus pentalophus **DC.**	Cactaceae		12
Echinopsis schickendantzii **F.A.C.Weber**	Cactaceae	1b	42
Echinopsis **sp.**	Cactaceae	1b	45
Echium plantagineum **L.**	Boraginaceae	1b	2358
Erigeron bonariensis **L.**	Asteraceae		20
Eriobotrya japonica **(Thunb.) Lindl.**	Rosaceae	1b	28
Erodium moschatum **(L.) L'Hér.**	Geraniaceae		797
Eucalyptus **sp.**	Myrtaceae	1b/2	865
Euphorbia pulcherrima **Willd. ex Klotzsch**	Euphorbiaceae		11
Ficus benjamina **L.**	Moraceae		32
Ficus carica **L.**	Moraceae		153
Ficus elastica **Roxb. ex Hornem.**	Moraceae		3
Ficus microcarpa **L. var. *microcarpa***	Moraceae		12
Ficus pumila **L.**	Moraceae		39
Foeniculum vulgare **Mill. var. *vulgare***	Apiaceae		210
Fraxinus angustifolia **Vahl**	Oleaceae		90
Fumaria muralis **Sond. ex W.D.J.Koch subsp. *muralis***	Onagraceae		5
Fumaria **sp.**	Fumariaceae		64
Gaura lindheimeri **Engelm. & A.Gray**	Onagraceae		276
Gelsemium sempervirens **Aiton**	Gelsemiaceae		1
Genista monspessulana **(L.) L.A.S.Johnson**	Fabaceae	1a	5
Glebionis coronaria **(L.) Cass. ex Spach**	Asteraceae		30
Grevillea robusta **A.Cunn. ex R.Br.**	Proteaceae	3	121
Grey date palm	Arecaceae	3	2
Hakea salicifolia **(Vent.) B.L.Burtt**	Proteaceae	1b	302
Hedera helix **L. var. *helix***	Araliaceae	3	164
Hedychium coronarium **J.König**	Zingiberaceae	3	15
Helichrysum **sp.**	Compositae		2
Hesperoyucca whipplei **(Torr.) Trel**	Asparagaceae		1
Hibiscus **sp.**	Malvaceae		214

***Homalanthus populifolius* Graham**	Euphorbiaceae	1b	3
***Hydrangea macrophylla* (Thunb.) Ser.**	Hydrangeaceae		2
***Hylocereus undatus* (Haw.) Britton & Rose**	Cactaceae	2	2
***Hypochaeris radicata* L.**	Asteraceae		148
***Ilex aquifolium* L.**	Aquifoliaceae		3
Ipomoea cairica* (L.) Sweet var. *cairica	Convolvulaceae		84
***Ipomoea purpurea* (L.) Roth**	Convolvulaceae	3	105
***Ipomoea* sp.**	Convolvulaceae	1b/3	22
***Jacaranda mimosifolia* D.Don**	Bignoniaceae		93
***Jasminum officinale* L.**	Oleaceae		28
***Lactuca* sp.**	Asteraceae		4
***Lagerstroemia indica* L.**	Lythraceae		67
***Lagunaria patersonia* (Andrews) G.Don**	Malvaceae		3
***Lagurus ovatus* L.**	Poaceae		9
***Lantana camara* L.**	Verbenaceae	1b	106
***Laurus nobilis* L.**	Lauraceae		19
***Lavandula* sp.**	Lamiaceae		247
***Lemna gibba* L.**	Lemnaceae		5
***Ligustrum japonicum* Thunb.**	Oleaceae	1b	6
***Ligustrum lucidum* W.T.Aiton**	Oleaceae	1b	42
***Ligustrum sinense* Lour.**	Oleaceae	1b	8
***Limonium perezii* (Stapf) F.T.Hubb.**	Plumbaginaceae		67
***Liquidambar styraciflua* L.**	Hamamelidaceae (Altingiaceae)		12
***Lolium* sp.**	Poaceae		44
Lonicera japonica* Thunb. var. *japonica	Caprifoliaceae	3	36
***Lupinus* sp.**	Fabaceae		60
***Lycianthes rantonnetii* (Carrière ex Lesc.) Bitter**	Solanaceae		121
***Lytocaryum weddellianum* (H.Wendl.) Toledo**	Arecaceae		6
***Macadamia* sp.**	Proteaceae		1
***Magnolia grandiflora* L.**	Magnoliaceae		3
***Malus domestica* Borkh.**	Rosaceae		1
***Malva arborea* (L.) Webb & Berthel.**	Malvaceae		13
Malva parviflora* L. var. *parviflora	Malvaceae		126
***Mammillaria* sp.**	Cactaceae		30
***Medicago sativa* L.**	Fabaceae		172
Melaleuca armillaris* (Sol. ex Gaertn.) Sm. subsp. *armillaris	Myrtaceae		1
Melaleuca bracteata* F.Muell. var. *revolution gold	Myrtaceae		45
***Melia azedarach* L.**	Meliaceae	1b	575
***Metrosideros excelsa* Sol. ex Gaertn.**	Myrtaceae		6
***Monstera deliciosa* Liebm.**	Araceae		54
Morus alba* L. var. *alba	Moraceae	3	67

***Myoporum tenuifolium* G.Forst.**	Myoporaceae	3	323
Myrtus communis* L. var. *communis	Myrtaceae		2
***Nandina domestica* Thunb.**	Berberidaceae		24
Nephrolepis cordifolia* (L.) C.Presl var. *cordifolia	Nephrolepidaceae	1b	107
***Nerium oleander* L.**	Apocynaceae	1b	109
***Nothoscordum gracile* (Aiton) Stearn**	Amaryllidaceae		50
***Olea europapaea* L.**	Oleaceae		937
***Opuntia elata* Link & Otto**	Cactaceae	1b	28
***Opuntia ficus-indica* (L.) Mill.**	Cactaceae	1b	116
***Opuntia microdasys* (Lehm.) Pfeiff.**	Cactaceae	1b	19
***Opuntia monacantha* Haw.**	Cactaceae	1b	9
***Opuntia* sp.**	Cactaceae	1a/1b	1
Opuntia stricta* (Haw.) Haw. var. *stricta	Cactaceae	1b	12
***Orobanche* sp.**	Orobanchaceae	1b	3
***Papaver* sp.**	Papaveraceae		211
***Parkinsonia aculeata* L.**	Fabaceae	1b	1
***Parthenocissus quinquefolia* (L.) Planch.**	Vitaceae		24
***Parthenocissus tricuspidata* Planch.**	Vitaceae		62
***Passiflora edulis* Sims**	Passifloraceae		41
***Pennisetum clandestinum* Hochst. ex Chiov.**	Poaceae	1b	5292
***Pennisetum setaceum* (Forssk.) Chiov.**	Poaceae	1b	218
Persea americana* Mill. var. *americana	Lauraceae		11
***Persicaria capitata* (Buch.-Ham. ex D.Don) H.Gross**	Polygonaceae	1b	1
***Persicaria lapathifolia* (L.) Gray**	Polygonaceae		65
***Persicaria* sp.**	Polygonaceae		2
***Phoenix canariensis* Chabaud**	Arecaceae		195
***Phoenix roebelenii* O'Brien**	Arecaceae		50
***Phormium tenax* J.R.Forst. & G.Forst.**	Hemerocallidaceae		2
***Phyllostachys* sp.**	Poaceae		113
***Physalis peruviana* L.**	Solanaceae		5
***Phytolacca dioica* L.**	Phytolaccaceae	3	6
***Phytolacca octandra* L.**	Phytolaccaceae	1b	11
***Pinus* sp.**	Pinaceae	1b/2	22
***Pittosporum undulatum* Vent.**	Pittosporaceae	1b	69
***Plantago lanceolata* L.**	Plantaginaceae		85
***Platanus acerifolia* (Aiton) Willd.**	Platanaceae		33
***Plectranthus barbatus* Andrews var. *grandis* (L.H.Cramer) Lukhoba & A.J.Paton**	Lamiaceae	1b	47
Plectranthus ornatus Codd	Lamiaceae		21
***Plumeria* sp.**	Apocynaceae		35
***Podranea ricasoliana* (Tanfani) Sprague**	Bignoniaceae		40
Pontederia cordata* L. var. *cordata	Pontederiaceae	1b	15
***Populus canescens* (Aiton) Sm.**	Salicaceae	2	268
***Populus deltoides* Bartram ex Marshall**	Salicaceae		11

***Populus nigra* L. var. *italica* Münchh.**	Salicaceae		274
***Populus simonii* Carrière**	Salicaceae		111
***Prosopis* sp.**	Fabaceae		5
***Prunus domestica* L.**	Rosaceae		16
Prunus persica* (L.) Batsch var. *persica	Rosaceae		82
***Prunus serrulata* Lindl.**	Rosaceae		3
***Prunus* sp.**	Rosaceae	1b	1
***Psidium cattleianum* Sabine**	Myrtaceae	1b	2
***Psidium guajava* L.**	Myrtaceae		65
***Punica granatum* L.**	Lythraceae		37
***Pyracantha* sp.**	Rosaceae		112
***Pyrus* sp.**	Rosaceae		3
***Quercus nigra* L.**	Fagaceae		37
***Quercus palustri*s L.**	Fagaceae		36
***Quercus palustris* L.**	Fagaceae		1
***Quercus petraea* L. ex Liebl.**	Fagaceae		22
***Quercus robur* L.**	Fagaceae		276
***Quercus suber* L.**	Fagaceae		4
***Raphanus raphanistrum* L.**	Brassicaceae		515
***Rhaphiolepis indica* (L.) Lindl.**	Rosaceae		32
Ricinus communis* L. var. *communis	Euphorbiaceae	2	350
***Robinia pseudoacacia* L.**	Fabaceae	1b	1
***Rosa* sp.**	Rosaceae		1076
***Rosmarinus officinalis* L.**	Lamiaceae		76
***Rubus* sp.**	Rosaceae	1b/2	1
***Rumex* sp.**	Polygonaceae	1b	23
***Ruscus* sp.**	Asparagaceae		3
Salix babylonica* L. var. *babylonica	Salicaceae		21
***Salix* sp.**	Salicaceae		8
***Salsola kali* L.**	Amaranthaceae	1b	10
***Salvia leucantha* Cav.**	Lamiaceae		1
***Salvinia molesta* D.S.Mitch.**	Salviniaceae	1b	5
Sambucus nigra* L. var. *nigra	Caprifoliaceae	1b	40
***Sansevieria trifasciata* Prain**	Asparagaceae		18
***Schefflera actinophylla* (Endl.) Harms**	Araliaceae	1b	4
***Schinus molle* L.**	Anacardiaceae		53
***Schinus terebinthifolius* Raddi**	Anacardiaceae	3	470
***Schizolobium parahyba* (Vell.) Blake**	Fabaceae		3
***Senna didymobotrya* (Fresen.) H.S.Irwin & Barneby**	Fabaceae	1b	20
***Sesbania punicea* (Cav.) Benth.**	Fabaceae	1b	165
***Sida rhombifolia* L.**	Malvaceae		178
***Solanum jasminoides* J. Paxton**	Solanaceae		3
***Solanum mauritianum* Scop.**	Solanaceae	1b	1
***Solanum nigrum* L.**	Solanaceae		137
***Sonchus* sp.**	Asteraceae		18

***Spartium junceum* L.**	Fabaceae	1b	1
***Stellaria media* (L.) Vill.**	Caryophyllaceae		6
***Syagrus romanzoffiana* (Cham.) Glassman**	Arecaceae		238
***Syngonium podophyllum* Schott**	Araceae		8
***Syzygium paniculatum* Gaertn.**	Myrtaceae		1095
***Tamarix* sp.**	Tamaricaceae	1b	5
***Taxodium distichum* (L.) Rich.**	Cupressaceae		5
***Tecoma stans* (L.) Juss. ex Kunth**	Bignoniaceae	1b	44
***Tipuana tipu* (Benth.) Kuntze**	Fabaceae	3	60
***Trachelospermum jasminoides* Lem.**	Apocynaceae		25
***Tradescantia fluminensis* Vell.**	Commelinaceae	1b	7
***Tradescantia pallida* (Rose) D.R.Hunt**	Commelinaceae		2
***Tradescantia zebrina* Bosse**	Commelinaceae	1b	2
***Tribulus terrestris* L.**	Zygophyllaceae		99
Trifolium angustifolium* L. var. *angustifolium	Fabaceae		274
***Tropaeolum majus* L.**	Tropaeolaceae		354
***Ulmus parvifolia* Jacq.**	Ulmaceae		8
Unidentified 1	Unknown		1
Unidentified 2	Unknown		1
Unidentified 3	Unknown		40
Unidentified 4	Unknown		1
Unidentified 5	Cactaceae		3
Unidentified 6	Unknown		1
Unidentified 7	Unknown		1
Unidentified 8	Unknown		1
Unidentified 9	Unknown		2
Unidentified 10	Cactaceae		22
Unidentified 11	Unknown		1
Unidentified 12	Unknown		1
Unidentified 13	Unknown		1
Unidentified 14	Unknown		17
Unidentified 16	Unknown		4
Unidentified 17	Unknown		1
Unidentified 18	Myrtaceae		2
Unidentified 19	Fabaceae		1
Unidentified 20	Myrtaceae		1
Unidentified Oak 2	Fagaceae		1
Unidentified Oak 3	Fagaceae		2
Unidentified Oak 4	Fagaceae		4
***Urtica urens* L.**	Urticaceae		104
***Verbascum virgatum* Stokes**	Scrophulariaceae		2
***Verbena bonariensis* L.**	Verbenaceae	1b	1
***Viburnum odoratissimum* Ker Gawl.**	Viburnaceae		47
***Viburnum tinus* L.**	Viburnaceae		1
***Vicia benghalensis* L.**	Fabaceae		402

Vicia sativa **L. subsp.** ***sativa***	Fabaceae		355
Vinca major **L.**	Apocynaceae	1b	136
Vitis vinifera **L.**	Vitaceae		86819
Washingtonia robusta	Arecaceae		306
Westringia fruticosa **(Willd.) Druce**	Lamiaceae		2
Westringia **sp.**	Lamiaceae		2
Wisteria floribunda **(Willd.) DC.**	Fabaceae		110
Xanthium strumarium **L.**	Asteraceae	1b	97
Yucca aloifolia **L.**	Asparagaceae		5
Yucca gloriosa **L. var.** ***gloriosa***	Asparagaceae		141
Yucca **sp.**	Asparagaceae		20